

## MAINTAINING ENTROPY: DEVELOPING SKILLS TO HELP GRADUATE SUSTAINABLE ENGINEERS LEAD CHANGE

H. J. Cruickshank<sup>1,3</sup>, C.M. Ainger<sup>1</sup>, R.A. Fenner<sup>1</sup>, P. Harding<sup>2</sup> and S. M. Owen<sup>1</sup>

<sup>1</sup> Centre for Sustainable Development, Department of Engineering, University of Cambridge, UK

<sup>2</sup> Cambridge University Careers Service, UK

<sup>3</sup> [hjc34@cam.ac.uk](mailto:hjc34@cam.ac.uk)

**Abstract:** Evidence is drawn from the 411 alumni of the MPhil in Engineering for Sustainable Development professional practice programme at University of Cambridge to examine whether the sustainability dimension of their education has i) provided them with a mix of skills which they use on a regular basis, ii) equipped them to be more effective in the roles they fulfil, and iii) given them confidence to act as agents of change in developing sustainability thinking and seeking out solutions that satisfy multiple constraints within their organisations. The relevance of the content of this sustainability programme is assessed and frustrations experienced by graduate sustainable engineers and the barriers to change are discussed.

### 1 CORE ELEMENTS OF SUSTAINABLE DEVELOPMENT CONCEPTS IN THE CURRICULA

In many cases, graduates from courses which explicitly include sustainable development concepts in their curricula now hold significant positions of responsibility within the engineering profession. This paper looks specifically at the legacy of the taught MPhil in Engineering for Sustainable Development (ESD) post-graduate course that has been offered at University of Cambridge, UK since 2002.

#### 1.1 Professional Roles

The course was established as a professional practice programme and has retained a significant focus on practical application of the concepts of sustainable development as relevant to engineers in their professional role. Components of the taught course include a consultancy project for an external organisation and seminar discussions with practitioners (Cruickshank & Fenner 2012). An emphasis is given to the role of the individual in an organisation and theory of organisational change is a core element of the curriculum. An opportunity for students to develop their professional skills and engage directly with external organisations is through their Dissertation research. Students often work directly on a problem identified by these organisations from their operations.

#### 1.2 Skills

Though the specific set of skills addressed by the course has evolved over the time that it has been operating, they have continuously addressed key areas of significance that could be broadly categorised as: systems thinking; acting as a change agent; whole lifecycle analysis; and dealing with other disciplines. These skills form the basis of the taught components of the course and are emphasised in other course activities (Fenner, Cruickshank, & Ainger, 2014).

### **1.3 Leading organisational change**

A particular aspiration of the course is that graduates will be able to act as **agents of change** in the organisations in which they are involved. There is recognition that this may be achieved through a variety of direct and indirect routes and with graduates acting individually or in collaboration with others.

## **2 STUDENT RECORDS, SURVEYS, INTERVIEWS AND OTHER DATA SOURCES**

Evidence here is drawn from sample surveys and interviews from the 411 alumni from the MPhil. Data is gathered via a range of types from statistical analysis of online survey to narrative reports from semi-structured interviews with individuals.

### **2.1 Student Data $n_d=411$**

General admission data on students' backgrounds is aggregated to give a general profile of the students by annual academic year group or collectively for the total alumni group. This is useful as a data baseline and to track similarities and differences between the cohorts. Data is collected for all 411 alumni of the course from academic year 2002-03 to 2013-14.

### **2.2 Social Media**

Students and graduates are invited to join a private LinkedIn group which has an active membership including discussions and job postings which provides data on work and educational history and current and past locations. While many of the individual year groups have their own Facebook groups, these are not maintained by or contributed to by the course staff. Of the 411 alumni 322 are members of the group (78% of those eligible). Facebook connections provide an additional way of reaching graduates but are not used for gathering data. Facebook was used for distribution of notices about the Alumni Survey and to share the SurveyMonkey link. 311 alumni are accessible to the course team via Facebook (76% of those eligible). Only 33 (8%) of those eligible are not connected by either of these social media.

### **2.3 In-depth interviews $n_i=21$**

Issues discussed with selected alumni covered: their background prior to the course; how they became aware of the course; what they expected when they applied and what they hoped to gain; their experience during the course; what they gained that they expected and that surprised them and what was missing that they had expected to be covered; what they did after the course; and how it has affected them in their personal life and career. Interviews were conducted either face-to-face or via Skype. In total 21 in-depth interviews were conducted (5% of the total eligible) each lasting approximately one hour.

### **2.4 Alumni Survey $n_s=142$**

An email to all graduates inviting participation in the survey contained a link to SurveyMonkey at [www.surveymonkey.com/s/73DT75S](http://www.surveymonkey.com/s/73DT75S). The text of the survey questions was included in the email and attached to it were three versions of the questionnaire in pdf form, SurveyMonkey form and word.doc formats. In total 142 responses were received and analysed. This equates to over 34% of those eligible. All but three of these were via the online option. There is a reasonable spread of samples across cohort years with approximately one third from each of the cohort groups and each geographical region represented by the survey respondents.

## **3 DISCUSSION**

This paper examines whether the MPhil has i) provided them with a mix of skills which they use on a regular basis, ii) equipped them to be more effective in the roles they fulfil, and iii) given them confidence to act as agents of change in developing sustainability thinking and seeking out solutions that satisfy multiple constraints within their organisations.

### 3.1 Skills

The skills that are taught on the course cover a range of recognised sustainability competencies and have formed the basis for the evolved rationale of the course over the years of its operation. Respondents were asked to rate the ten skills listed in the alumni survey on a five point Likert scale. The survey also asked supplementary open-ended questions about which skills were valued and used in practice and which key skills were perceived as missing from the course.

#### 3.1.1 Overall rating of skills as described in the survey

All of the skills that were rated obtained over 50% of responses in the “Very useful” or “Somewhat useful” categories but there is a noticeable difference in overall rating. Skills particularly well rated are **“taking a systems approach to dealing with complex problems”**, **“communicating successfully with other disciplines”** and **“considering environmental and social constraints”** but so too are **“managing uncertainty in the absence of complete information or evidence”**, **“dealing effectively with people”**, and **“recognising where trade-offs are necessary”**. Less rated are **“enabling organisational change”**, **“working within environmental limits”**, **“using sustainability tools and techniques for measurement”** and **“adopting life-cycle management”**.

#### 3.1.2 Skills used by graduates on a regular basis

Thinking retrospectively about which skills are used on a regular basis there is a range of views from respondents. One 2005-06 graduate makes the important point that it is necessary to question *“whether these skills came from the MPhil or other places”*. Some skills are more explicitly taught now in response to recognition of changing demands. This evolution of the course content is crucial for maintaining the relevance of the material to the changing requirements of their workplaces. The general themes of the skills covered are, however, still recognisable to all alumni who were able to reflect on their usefulness.

The range of skills covered is recognised as giving graduates an ability to take a broad perspective on complex problems. 2007-08 graduates from Lebanon and UK respectively sum this up well saying *“it allows me to have a holistic approach when making a complex decisions, therefore taking into consideration the perspectives of different stakeholders”* and *“I am better able to be objective when faced with different points of view, and take decisions that consider the bigger picture”*. A Vietnamese graduate from the previous cohort (2006-07) emphasises the self-reflection that this brings *“I become more critical in my thinking and holistic in my view of problems”* and her Argentinian contemporary, currently working as Industrial Development Officer, in UNIDO in Austria says *“In the technical design of policy programmes, having a holistic view is key. In addition, being able to liaise with multiple stakeholders and to communicate effectively with all of them is the basis of multilateral technical assistance”*.

When undertaking multi-disciplinary projects that are commonly encountered by the graduates the ability to communicate and the soft skills necessary to engage with a range of stakeholders is another recognised benefit. A Chilean 2011-12 graduate values *“the technical and personal abilities in order to make change happen”* and 2010-11 Cypriot notes that these skills *“Enabled me to smoothly transit between commercial and technical roles and effectively communicate with and approach people from both disciplines”*. A 2008-09 US graduate who is currently Post-Crisis Environmental Advisor / AAAS Science & Technology Policy Fellow, at USAID emphasises this point that these skills help *“By allowing me to manage projects that integrate a variety of disciplines, ask the right questions, and bring in the right people from those disciplines to come to a coordinated and meaningful sustainability result (analysis, plan, etc.)”*. Building on this, 2011-12 Nigerian graduate is typical saying *“Interactions on the programme exposed me to soft skills that helped me to manage a team of 80 engineers of different disciplines and moderate communications with the client and my organization's management”* in Nigeria.

Linked to this is the important aspect of increased confidence necessary to bring about the desired changes. 2003-04 UK graduate who was sponsored by consultants Black and Veatch to take the course as a year out from his 30 year career says the skills learned *“Increased confidence in my assessments of situations, technology and people, allowing me to deal with the human nature issues and effects and keep going”*. Similarly, Malaysian 2012-13 graduate says *“They enable me to make decision confidently”*

and Cypriot graduate of 2010-11, now working as Power System Engineer for National Grid in UK recognises that developing these skills are *“Invaluable following a technical engineering undergraduate degree as these are the true factors that distinguish an individual in a working environment”*.

### **3.1.3 How these skills have equipped graduates in their role**

Alumni comments can be grouped into these three main categories: taking a holistic view; effective engagement and communication with stakeholders; and confidence to implement change.

2006-07 US graduate says *“We often are required to take a holistic view of problems that our client may have missed. ESD did a great job of preparing me for that”* and 2013-14 graduate says *“I tend to take a broader look at complex issues and try to relate them to longer term solutions”*. Similarly Nigerian 2011-12 graduate now working in UK says *“these skills have widened my horizons and broadened my perspectives on complex issues surrounding engineering projects. These skills have equipped [me] to be a more effective decision maker and professional engineer. I am also able to research subject matters and issues effectively hence improving the quality of my decisions”*. Indian 2012-13 graduate notes that the skills taught on the course have *“1) enabled me to understand and define problems better - thereby leading to better problem solving 2) It has helped me negotiate better in situations where I am proposing an environmental solution or a better practice 3) Trying to understand the perspective and more importantly the motivation of stakeholders helps in identifying levers for change 4) Improved my ability to link different subjects in a coherent manner”*. That ability to communicate itself brings benefits as highlighted by 2011-12 Australian graduate *“The daily communications and interaction give me far greater confidence in contributing to work environments”* and from 2013-14 Mexican graduate, *“These skills provide a view very different than that of a common senior manager, hence the input I can provide brings a whole new point of discussion”*. The course provides *“Preparation for dealing with different stakeholders with varying interest in green issues”* says 2011-12 UK graduate and 2007-08 South African graduate notes that *“Much of my work has had to do with changing organisational paradigms in moving towards truly a customer-focused organisation. This has drawn from skills such as being able to effect organisational change, [...] and working with cross-functional stakeholders with often differing mandates”* and Brazilian from the same cohort now working as Proposals Engineer at WPL, a supplier of packaged wastewater treatment plants based in, UK says that the soft skills taught *“definitely increased my ability to ‘read’ and manage people, which I use on a daily basis”*.

2010-11 Canadian graduate notes that the skills developed on the course are valuable *“not only in sustainability, but in leadership and in influencing others towards positive change”* emphasising the transferability of the lessons. This general enhancement is recognised by 2007-2008 Greek graduate who says the course *“Made me more flexible in adapting in new situations, more effective in communicating with others, [take a] broader perspective of the world, economy, environment [and be] stronger in trying to implement sustainability within my field of work”* as an Independent Consultant Engineer, collaborating with other engineers, companies, governmental organizations and universities. Similarly, 2008-09 US graduate said *“I was able to speak effectively from a point of knowledge and convince people that I was competent”* and two of her Canadian contemporaries mention that the course has *“Given me confidence with uncertainty and a more grounded approach to problems that go through multiple iterations, with several different team members”* and even *“Provided me with new language, tools and problem-solving techniques [that] gave me confidence to undertake an important career change”*. Serbian 2009-2010 graduate says the course *“made me more confident and comfortable with dealing with incomplete information, trade-offs”* and 2003-2004 UK graduate noted that the course *“Improved my confidence to believe I'm making the right decisions based on gathered information and to question”*.

In general, rather than deepening and enhancing technical knowledge the course has empowered graduates to apply what they know and develop the skills required to negotiate and communicate with multi-disciplinary teams in the absence of complete information or precedent for proposals.

### **3.1.4 Skills that graduates think important but perceived as missing from the course content.**

Graduates also considered which skills were perceived as missing from their version of the course. One 2007-08 graduate requested *“More leadership, negotiation and managerial skills”*. The role of the

individual in leading organisation change has subsequently been acknowledged and enhanced in the teaching of the material. A graduate from a later cohort (2011-12), however reflected *"I think leadership in difficult times and change management could be further developed"* showing that more still needs to be done to teach this skill effectively. Similarly, while **"Managing uncertainty in the absence of complete information or evidence"** and **"Dealing effectively with people"** are fairly highly rated, a 2006-07 graduate commented that *"ultimately achieving sustainability is about persuading people. The course lacks a module on the psychology of sustainability and risk"*. Recognising the need for a combination of the skills taught, a graduate of the most recent cohort (2013-14) suggested that more guidance was needed on *"Managing managers to initiate change"*. This is reiterated by an earlier (2008-09) graduate suggesting that *"soft skills like how to convince your manager to spend money"* are further required, she also suggested that, despite **"Using sustainability tools for measurement"** being less highly rated than other skills, that *"Using sustainability data software (GHG inventory tools and the like)"* and *"Legislative reporting requirements"* are required and a later graduate (2012-13) said *"I would have found [it] beneficial to get further tools and techniques for measuring and analysing sustainability, or a more detailed understanding on how to use the tools we were introduced to"*. A 2012-13 graduate suggests there is a need to enhance *"Ability to analyze the success / failure of previous interventions / projects by considering other aspects beyond technical solutions"*.

Alumni appear to consider deeply the need to develop skills to engage their organisation's managers in order to bring about change. 2011-12 graduate suggests more on *"How to engage top management on sustainability issues"* and 2009-10 graduate asks for *"some business-oriented angles"*. Several alumni suggested the need for more business skills training such as 2009-10 graduate who asked for *"Maybe more content on building the business case for sustainability"* but recognised that this may be outside the scope of this course.

Others see the need for practical skills such as "Negotiation", graduates from 2006-07 and 2008-09 specifically mentioned this; and "Facilitation techniques" (2008-09 graduate) and "Basic consulting and engagement skills / tips / tricks" (2012-13 graduate). Also, recognition of the cultural context of decisions, for example *"Maybe some elements about cultural perspectives and anthropological analysis, taking into account that many sustainability problems are deeply rooted in cultural aspects"* says Chilean 2010-11 graduate.

### 3.2 Effectiveness

In terms of the roles that graduates see themselves in 83% ( $n_s=142$ ) feel they are **"in a formal 'sustainability' role** (interpreting widely e.g. environmental consultant, CSR, sustainability manager etc.);" or "doing things on sustainability but **outside their formal job description**". Of the 17% doing **"no work on sustainability"** the reasons include being in a junior role, as a recent (2013-14) Nigerian graduate working in UK said *"my role does not involve a great deal of project management or activities that can significantly influence project outcomes"* or they are conducting research and therefore could not currently be said to be influencing others at this stage says 2010-11 Mexican graduate now studying for PhD at Cambridge.

Others feel equipped to make changes but sometimes graduates feel that sustainability is not core to their organisation's interests, 2012-13 Chilean graduate says *"Every day I feel like an infiltrator within the company"* and they do not have sufficient seniority to apply their sustainability interests or it is not of prominence in their region *"Profit-based organisation requires staff to focus and to devote more effort on improving productivity, efficiency, revenue and profit. However, it provides me an opportunity to bring more changes to the industry since sustainability has not been given much attention by the people in South-east Asia"* says a Malaysian 2012-13 graduate in Singapore. Alternatively, a contemporary of that cohort, an Australian working in London, UK says *"There is a broader focus on sustainability for the projects I work on, but I don't really get involved (not through a lack of trying!)"*. Other times graduates are doing good sustainability interventions that are just part of regular work, 2009-10 Chilean graduate says *"I apply the sustainable concepts into my day to day work, but it is not a 100% part of my job description"*.

On the other end of the spectrum, around 42% ( $n_s=142$ ) of respondents consider themselves to have a formal role and may be in a position of seniority in an organisation and working in appropriate sectors, for

example 2003-04 graduate in Greece says *“The sector I work for is by default engaged in sustainability, although naturally its sustainable nature sometimes gets into conflicts with corporate / financial interests. As a project manager I get extensively involved in Environmental and Social matters and also CSR and CSV for my projects”*, the skills he developed on the course, he says are *“[...] deeply engrained in my mind and are part of my everyday thinking”*.

### 3.3 Change

In the survey responses and interviews, “confidence” is mentioned many times as something explicitly gained from the course. Whether that be from the qualification itself, the Cambridge University experience and the reputation that it carries outside, interactions with classmates and staff or from the actual material studied is less clear, but increased confidence is evidently a significant outcome of participation in the course. Confidence is recognised as an important pre-requisite for becoming an agent of change in any type of organisation and may take the form of self-confidence of the graduates in themselves to be agents of change but also confidence of others in them to credit their expertise. This is borne out by the various roles that graduates take. 22% of survey respondents describe themselves as “Taking a **‘leader’** role (formally or informally) helping bring others forward” with a total of 61% describing their role as acting individually, as an **‘expert’** with special knowledge in sustainability (15%), a **‘facilitator’** or **‘catalyst’** (15%), an **‘advocate’** or **‘activist’** saying where we need to go (12%), an **‘internal innovator’** doing the first time newest stuff on sustainability in the organization or embedding the new stuff in standard practice (12%), or as an **‘entrepreneur’** starting new, more sustainable organizations in the sector (7%). Only 11% are acting formally as a **‘consultant’** for sustainability and the remaining 6% are acting as a **‘regulator’** for the sector for greater sustainability.

Considering their attempts at bringing about change in their organisations, 50% ( $n_s=142$ ) of respondents reported being wholly or mostly successful. Recognising that organisational change is an ongoing process 2004-05 graduate reports a *“Mix of successes and failures - nevertheless the failures provide the best lessons in my experience”* and 2009-10 graduate says *“I constantly learn from my mistakes, other people’s mistakes, and my successes and other people success. I analyse a lot what is done good and bad, and instead of looking [for] someone to blame [for] the mistakes, I use them as opportunities to learn and improve and communicate it to all my department”*. Some, such as 2011-12 graduate who now has his own company operating out of Ecuador can claim to have *“100% succeeded, given that I lead my own company”* whereas most report being broadly successful in their change attempts such as 2012-13 graduate who says *“I believe achieving a 100 per cent success i.e. finishing the process of change completely - in situations where it was possible - was something I was unable to do due to: inexperience; maybe a lack of maturity; being too personally invested; [and] fear of success”* emphasising again that graduates’ own assessments of their success is influenced by their levels of self-confidence. Even those with more post-course experience still question their influence and recognise that the organisation needs to be receptive to change. For example, 2006-07 Chilean graduate says *“I would like to say that I have succeeded in taking action for change, but it is too optimistic to think like this. After I completed the MPhil I was convinced that my role should be in the sustainability field. First, as a sustainability consultant it was difficult to cope with change in companies located in Chile and of the region. Business companies’ sustainability is not priority and it is really hard to make them interested to cope with change. In the current company in which I am working the situation is not so different. However, there is more interest as this is a natural resource company with business interests in the pulp and panel industry”*.

In some cases graduates recognise that it is the scale of the change attempt that is important, typical of others 2013-14 graduate noted that they were *“Succeeding in smaller work activities and projects 100%. Succeeding in implementing broader structural, organisational or industrial change 0%”*. Similarly Canadian 2010-11 graduate says *“Somewhere in the middle - succeeded in some forums (bringing it to the agenda & dialogue), failed in others (realising widespread organisational change around sustainability attitudes)”* and 2008-09 UK graduate said *“I have had some small successes in getting sustainability more routinely considered in the organisation, and as part of refurbishments in the organisation. Within design teams as a consultant I have had some small successes in getting clients to go further than they would have otherwise. In general however the majority of the time my role has meant communicating and helping to achieve what is required by legislation and no more”*.

## 4 REFLECTION

### 4.1 Syllabus content

From these surveys perceived gaps in syllabus content were examined. Over the years of delivery the course has changed incrementally. A graduate from the first cohort, 2002-03 noted that *“Energy challenges, potentially the biggest challenge to our generation wasn't covered enough in that first course, it may have changed since”* and similarly, 2007-08 graduate said *“more energy specific optional courses would have been helpful”*. Indeed, energy issues have become more prominent in recent years being a strong focus for many of the students, as reflected in their Dissertation topic choices and in the increasing number of sustainable energy related option courses available. Several graduates asked for a more philosophical approach for example, 2003-04 graduate requested *“Time to fit in the Philosophy element. This would have helped me come to terms with human inertia and how to harness our worst traits and, somehow, turn them to our collective advantage”* and 2007-08 graduate asked for *“Different modelling approaches. Philosophical differences in approaches”*. Some of these elements may have been available to students through the elective modules offered to them and it may be that with the benefit of hindsight based on their current value perception that alumni may have made different choices while compiling their own individual course profile.

### 4.2 Alumni profiles

Although from diverse backgrounds and with a range of expectations, alumni have some significant traits in common. A 2012-13 graduate summarises this well when she says *“Like most engineers, I came into the MPhil seeing things in black and white - where there was a straight forward, technical sound solution to every problem. Learning the above mentioned skills really helped prepare me for the 'grey' areas one is constantly faced with when working in development. These are mainly associated with dealing with people (from funders to beneficiaries), managing expectations and accepting that there are different ways to approach a problem”*.

### 4.3 Career trajectory

68% of survey respondents have 1-10+ years' experience prior to coming on the course (45% having 1-5 years). A smaller subset have no prior work experience but may have worked with voluntary organisations or through internships. Many have successful jobs and promising career trajectories in companies and the reasons given for leaving this and joining the course ( $n_i=21$ ) include: a desire for further and broader education; a chance to open new opportunities; an opportunity to live in another country; and initiating a change to a different sector or discipline. A number of graduates have gone on to paid employment in the organisations with whom they conducted their Dissertation work. This has been seen to facilitate their transition from one sector or location to another. Notable examples include 2013-14 UK graduate who took a job with Cambridge start-up company Azuri who produce pay-as-you-go solar home systems in East Africa after working with them on his Dissertation and thereby transitioned from his previous employment in the water sector. Similarly, 2012-13 Australian graduate worked with Canadian NGO CAWST (Centre for Affordable Water and Sanitation Technology) and moved from Sinclair Knight Merz in Adelaide and is now based in Calgary, CA.

### 4.4 Sharing successes

Alumni recognise the lessons to be shared amongst their network. South African 2012-13 graduate requested that experiences of previous graduates should be used further to augment the class learning *“The challenges faced with working in a developing country were touched on regularly during the course. I would recommend that this be elaborated on in more detail- possibly through a 'lessons learned' set of seminars where professional / alumni working in the field share their experiences”*. In a similar vein 2011-12 Nigerian graduate asked for *“Professional Mentorship for Individuals returning to practice [and] Mentorship for Individuals who intend to transition into Sustainability consultancy or academia”*. This is largely covered by the Practitioner Viewpoint seminars that form a core part of the course. It is, however, difficult to pin down exactly what is perceived as a success, as a 2007-08 graduate says *“Sustainable development requires such massive shift from what we are doing presently that it is really difficult to*

assess how you are doing personally under such a gargantuan undertaking. How can you measure success? Is successfully publishing research on sustainable development considered as successfully taking action on change? Or is designing a building to use less concrete all that is required? Everybody in their own way is trying to do their bit. Everybody is failing and everybody is succeeding. [...] The less you know about sustainable development the more you think you are doing your bit and (broadly) succeeding. On the other hand, the more you know about sustainable development the more you know how much needs to be done and the more likely you are to think that you are largely failing.”

#### **4.5 Frustrations and limitations**

It is clear that graduates have high aspirations for their own role and other people’s consideration of sustainability in professional practice. 2009-10 graduate reflected that *“The working world can be very ‘cynical’ for a student who is coming straight from the university and has never worked before and faces the reality of ‘selling his / her soul’ in a job that provides food. Also, he / she will face people that will have to work on anything to get money, and that can be a problem when it collides with a more sustainable approach”*. In terms of the interaction between professional and personal aspects of life, these are intimately intertwined. As one UK 2006-07 graduate said *“It’s a sad reality of life that when I was looking for roles in Zurich, sustainability roles were largely out of reach [...] I sort of fell into Google (happily), and since then have been working out what I want to do with my life (thus the regular role and team changes). I often look for opportunities [...] but these are usually constrained by location”*.

Change also leads to difficult personal reflection. Mexican 2010-11 graduate currently working in US laments *“So far, in my current role, I have failed. I’m dealing with people that are not used to change, and without a lot of technical knowledge. Upper management in my company is fairly busy so they do not have a lot of time for me, I feel like I work in a vacuum sometimes”*. Reflecting that meaningful change takes time, recent (2013-14) US graduate says regarding how successful their change attempts have been it is *“Still too early to say definitively. I feel that I am positioning myself to enact change, but the seeds I’ve been planting need time to mature before I know if I have been successful or not”* showing that maturity and hindsight are useful when assessing impact. 2005-06 US graduate emphasises this saying *“The efforts were long-term and often felt for years like they would end in failure but all ended in success”*. Graduates appear to be generally realistic about the process 2007-08 graduate feels he has *“Succeeded (humbly of course). However, it’s never enough, and there is so much I could do more. It’s all about funneling the energy at the right time and the right place”*.

## **5 CONCLUSIONS AND RECOMMENDATIONS**

The ability for engineers and scientists with deep technical backgrounds to consider issues more holistically is seen as of great importance by the graduates who recognise that they need to work with inter-disciplinary teams or even take on a more multi-disciplinary role themselves. With this comes the recognition of the need for and value of soft skills associated with communication and negotiation. The confidence that students gain through their participation in the course to undertake these roles is seen as a great strength. More emphasis on the content in these areas could improve the course in future.

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### **References**

- Cruickshank, H.J. and Fenner, R.A. (2012) Exploring key sustainable development themes through learning activities. *International Journal of Sustainability in Higher Education*, Vol. 13 No. 3, p 249-262
- Fenner, Richard A., Cruickshank, Heather J. & Ainger, Charles (2014) Sustainability in civil engineering education: why, what, when, where and how *Proceedings of the Institution of Civil Engineers, Engineering Sustainability* Volume 167 October 2014 Issue ES5, Pages 228–237